High-Temperature Superconductors in Underground Communications

- **Principal Investigator:** David Reagor- Los Alamos National Laboratory
- **NETL Project Manager:** Morgan Mosser
- **Partners:** RAG Coal, CONSOL, Inc., Hecla Mining, Asarco, Phelps-Dodge, Molycorp, Stolar Horizon, Harris Communications
- **Total Project Cost:** **$2,142 K**
  - DOE Share: $1,071 K
  - Participant Share: $1,071 K
- **Project Period:** **48 months**
- **Project Start Date:** **Sept 1, 1999**
  - No cost time extension till Mar. 31, 2003

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High-Temperature Superconductors in Underground Communications

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Project Objectives

- **Develop and deploy a compact, sensitive wideband receiver for low-frequency underground communications signals, using high-temperature SQUID (superconducting quantum interference device) technology**
- **Increase the productivity of underground mining operations by about 5% resulting in a 5% energy savings per unit production**
  - Receivers can be placed in small packages that can be easily carried by miners in an underground environment
  - Easier to install and maintain than hard-wired technology

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Milestones and Status

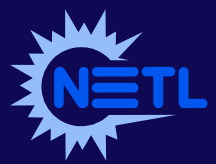
Major Milestones Planned to Date/Status

Planned Milestone	*Scheduled*	*Completed*
– Field testing of background noise in mines	06/1999	06/1999
– Evaluation of industry communication needs	12/1999	12/1999
– Identify effect of MSHA requirements on system	12/1999	12/2001
– Demonstrate high-quality audio in lab	06/2000	05/2000
– Field demonstration of the digital audio	06/2000	08/2000
– Demonstrate long range audio to the consortium	06/2001	06/2001
– Design and build portable transmitters	06/2001	04/2001
– Transfer device fabrication to economical substrates	12/2001	12/2001
– Complete production prototype	06/2002	underway*
– Field demonstrate 2-way portable radio	12/2002	12/2002
– Transfer technology to communications partner	03/2003	underway**

*see attached project note..

Key Accomplishments

- **Project Highlights**
  - We had our first successful field test of a two base station combination at the Molycorp, Inc. facility in Questa, NM. Our standard base station antenna is now a very inexpensive copper loop that can be cable tied to the tunnel mesh. We built a nearly identical antenna to establish two-way base station communications. This is the last significant technical goal of the project.
  - The patent for the audio version of the underground radio has been approved by the LANL internal review process. The final version should be submitted to the U.S. PTO within a few months.



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Project Note

*The production prototype milestone has been delayed pending interactions with our potential vendors.

**The vendor situation has changed. I received official word from Motorola that the market for underground radio is too small for their company. They were complementary toward the technical work, and suggested finding a smaller business.

Good News!

- Our vendor for part of the underground radio system is willing to join a consortium to build a demonstration system in a mine. The concept is to take part of the underground radio system and use it to complete through-the-earth links in underground mines. The underground radio links would consist of repeaters that connect areas served by leaky feeder or line-of-sight systems. This will turn a vulnerable, singly connected system into a redundant multiply connected network, and also allow communications in areas that are currently difficult to serve. This is an immediate term application using items that have been demonstrated in the course of the project.

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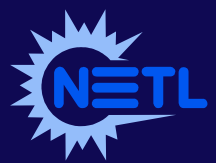
Drilling and Blasting Optimization

- **NETL Project Manager:** David M. Hyman
- **Cost-Sharing Partners:** University of Arizona; Phelps-Dodge Morenci; Split Engineering; and Aquila Mining Systems, Ltd.
- **Principal Investigator:** Deborah Hopkins - LBNL
- **Total Project Cost:** **$1,636K**
  - DOE Share: $720K
  - Participant Share: $916K
- **Project Period: 48 months (12 month no-cost extension)**
- **Project Start Date:** August 1999



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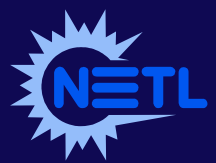
Project Objectives

- To develop real-time sensors and data acquisition and imaging systems to increase and better quantify data obtained during drilling.
- To integrate data collected during drilling into an analysis tool to optimize subsequent drilling and blasting and routing of blasted rock, thereby increasing the quality of mill feed.



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Project Objectives

- **To develop and implement:**
  - Prototype measurements-while-drilling (MWD) geophysical field system to characterize the rock mass surrounding the borehole.
  - Sample collection and analysis system to allow real-time measurements of mineral content in the borehole during drilling.
  - On-line, adaptive, blast-design tool based on analysis of data collected during drilling.

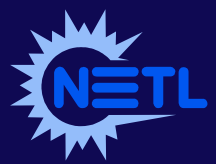
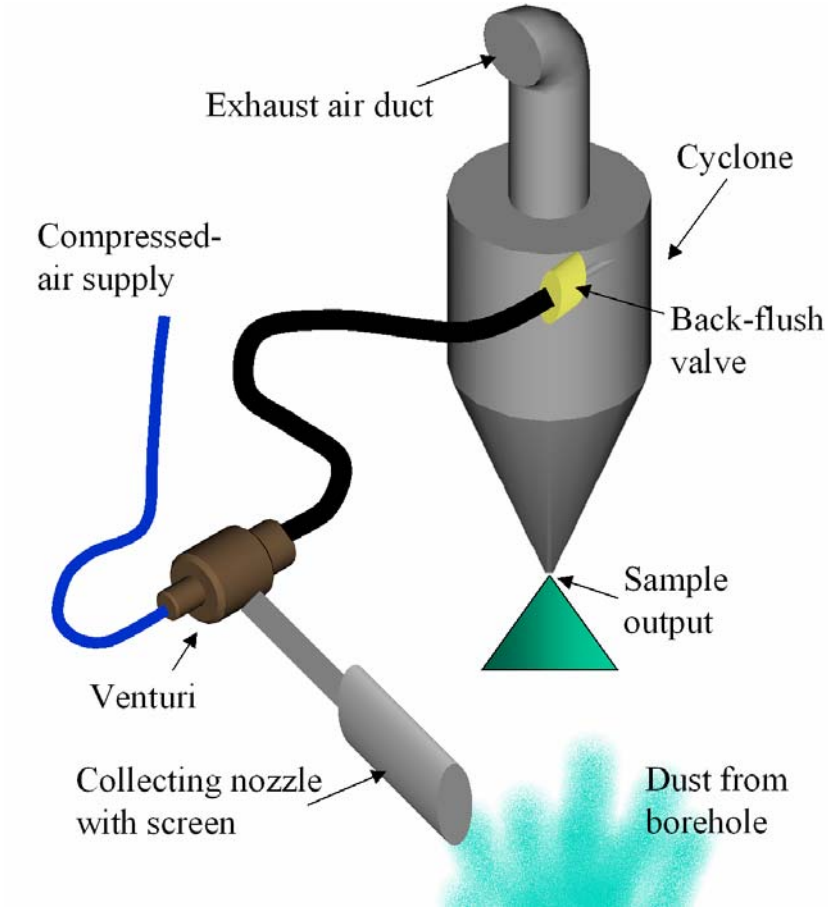


Photo Library - 1

Installation of steel collar housing accelerometers and a wireless transmission system on a drill rig for March 2002 field test.



Schematic diagram of dust/cutting collection system (see data displayed on following page).

Photo Library - 2

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Photo Library - 3

Accelerometers
Bandwidth: 400 Hz, Range: +/- 40g
Sampling rate: 2000 samples/sec/channel
Wireless transmission system via FM radio at 418 and 433 MHz

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Milestones and Status - 1

Task:

Design and execute field tests (details on following slides):

Planned milestone	Status/Completion date
Convene kick-off and project planning meeting.	10/1999
Conduct field tests to test systems under development and collect data.	10/1999, 1/2000, 5/2000 6/2000, 9/2000, 5/2001, 6/2001, 9-12/2001
Conduct full-scale field test.	3/2002

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Milestones and Status - 2

Task:

Develop radar system for rock mass characterization

Planned milestone	Status
Conduct field test of radar system; analyze cross-well data.	7/2000
Modify radar equipment for survey that will use zero-offset profile method to obtain arrival time vs. depth in adjacent boreholes. Conduct field test.	3/2001 5/2001
Construct algorithms to produce 3-D images of the rock-mass.	Ongoing at the Univ. of Arizona
Conduct third field test.	3/2002

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Milestones and Status - 3

Task:

Develop acoustic system for online analysis of drill vibration data for fracture identification:

Planned milestone	Status
Fabricate housing for accelerometers suitable for installation on a drill rig. Install and test electronics and data acquisition system.	1/2001 3/2002
Install accelerometer package and associated data acquisition system on drill rig. Perform second field test of acoustic vibration system.	5/2001 3/2002
Complete first online measurements of drill vibration data during drilling. Complete second online measurements of drill vibration data during drilling.	5/2001 3/2002
Determine post-processing necessary for drill-rig vibration data obtained during drilling.	Ongoing

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Milestones and Status - 4

Task:

Design and fabricate system for collection of dust/cuttings during drilling:

Planned milestone	Status
Design prototype system that allows continuous sampling of dust/cuttings during drilling. Modify prototype system for improved durability and ease of use in the field.	1/2001 3/2002
Fabricate and perform laboratory tests on prototype system.	3/2001
Install prototype on drill rig.	5/2001
Conduct first field test of prototype; collect samples during drilling for subsequent XRF analysis. Conduct second field test of prototype system and collect samples.	5/2001 3/2002

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Milestones and Status - 5

Task:

X-Ray Fluorescence (XRF) spectroscopy of field samples:

Planned milestone	Status
Complete x-ray fluorescence spectroscopy on field and reference samples.	10/2000
Analyze more than 200 samples obtained from the mine using XRF spectroscopy to obtain mineral content.	6/2000, 7/2001
Develop post-processing techniques for XRF data.	7/2001
Identify samples with similar elemental composition using statistical techniques. Summarize initial results in paper submitted for publication.	2/2002 2/2002
Map elemental composition of boreholes on the test bench. Develop 3D mapping technique for bench.	8/2001 Ongoing

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Milestones and Status - 6

Task:

Develop on-line adaptive blast-design tool based on data collected during drilling:

Planned milestone	Status
Complete post-blast fragmentation characterization.	8/2000
Analyze data from several blasting shots: experimental high-energy shots and shots using normal blasting parameters.	6/2001
Calculate specific energy for drilling vs. depth calculated for each blast hole based on drilling data.	7/2001
Calculate average information for each blast hole including average drilling energy, average explosive energy, average F80, average P80, and average Bond Index. Refine blast model.	8/2001 Ongoing at U. Arizona

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Milestones and Status - 7

Task:

Develop on-line adaptive blast-design tool based on data collected during drilling:

Planned milestone	Status
Integrate and analyze blast-hole modeling data (torque, downhole pressure, penetration rate, and rotation speed vs. depth), blasting parameters (hole energy, layout, timing), and data from the Split system installed at the primary crusher (F80, P80).	8/2002
Determine relationships between drill and blast data, and rock properties and fractures. Perform laboratory tests to relate energy consumption to size reduction.	9/2002
Modify blast prediction model to include fracture and drill data.	Ongoing at U. Arizona
Video image bench face to obtain fracture data.	5/2001
Conduct full-scale field test.	3/2002

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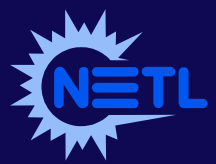
Milestones and Status

Key Decision Points Remaining

- **Determine viability of using drill-vibration data to detect fractures**
- **Determine viability of geophysical borehole measurements for rock-mass characterization**
- **Determine rock-mass and drilling data that is most predictive for blast results**
- **Determine what data should be incorporated into the adaptive blast-design model**



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Milestones and Status

Key Decision Points Remaining

Decision point	Scheduled date	Is it a go/no-go decision?
Determine viability of using drill-vibration data to detect fractures.	9/2002	Yes, for using vibration data
Determine viability of geophysical borehole measurements for rock-mass characterization.	9/2002	Yes, for using borehole data
Determine viability of continuous sampling of dust/cuttings during drilling to measure mineral content.	11/2001	Yes, but sampling still possible at discrete intervals
Determine viability of making x-ray fluorescence (XRF) spectroscopy measurements in the field.	3/2002	Yes, but XRF meas. can be made offline
Determine rock-mass and drilling data that is most predictive for blast results.	9/2002	No
Determine what data should be incorporated into the adaptive blast- design model.	9/2002	No

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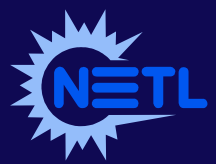
Technology Transfer

Papers and presentations	Date
Project overview presented at National Mining Association's Convention '99, St. Louis	October 10-13, 1999
Paper presented and published in Proc. 4th North American Rock Mechanics Symp., Seattle,	7/2000
Exhibitor at MinEXPO 2000 Las Vegas	October 9-12, 2000
Presentation at Geological Society of America Annual Meeting, Reno, NV	November 9-18, 2000
Exhibitor at OIT 4th Industrial Energy Efficiency Symposium, Washington D.C	Feb 19-22, 2001
Two papers presented and published at 38th U.S. Rock Mechanics Symposium, Washington D.C.	**July 2001**
Paper presented and published at the Society for Mining, Metallurgy, and Exploration (SME) conference in Arizona	2/2002
Two papers presented and published in Mining and Tunneling- Innovation and Opportunity, North American Rock Mechanics Symposium (NARMS), Toronto, Canada	**7/2002**

Key Accomplishments

- Progress to Date Highlights
  - Several field tests completed
  - More than 200 samples from the mine analyzed for mineral content using x-ray fluorescence (XRF) spectroscopy
  - Post-processing techniques for XRF data developed
  - Samples with similar elemental composition identified using statistical techniques
  - Depth versus mineral content mapped for test bench
  - Seven papers published
  - Post-blast fragmentation analysis completed
  - Laboratory tests to determine relationship between energy consumption and size reduction completed



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Key Accomplishments

- Progress to Date Highlights (Cont'd)
  - Integration and analysis of blast-hole data, drilling data (torque, down-hole pressure, penetration rate, and rotation speed vs. depth), blasting parameters (hole energy, layout, timing),and data from the Split system installed at the primary crusher (F80, P80) completed
  - Blast-prediction model improved
  - Prototype system installed that allows continuous sampling of dust/cuttings on the drill rig during drilling
  - Radar equipment modified to allow measurement of arrival time vs. depth in adjacent boreholes
  - Analysis of cross-well radar data completed
  - Steel collar housing accelerometers and a wireless data transmission system fabricated and installed on a drill rig; data successfully collected during drilling
  - Fracture map completed for test bench

Good News!

The project focuses on optimization of blasting to achieve optimal fragmentation of rock. Improved blasting practices that lead to better control of fragmentation can result in substantial economic benefits. Although the proposed technology would increase the cost of drilling and blasting, substantial improvements in process plant throughput have been shown to significantly reduce costs downstream. The potential energy savings resulting from improved blast performance can also be substantial, and there are significant environmental and safety benefits as well. For example, optimal rock fragmentation results in tremendous energy savings during crushing and grinding, and substantially increases leach recovery. Improved blast designs reduce undesirable blast vibration effects and minimize the potential for damage to structures in the vicinity of the mine. Wall stability is improved, thereby improving the safety of the mine, and blast noise and dangerous flyrock are also reduced.

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Good News!

The technical goals of the project include development of sensors, data acquisition systems, and online analysis tools that will allow real-time characterization of the rock mass and bore-hole measurements of mineral content. In addition to optimizing blasting strategies, knowing the exact location of waste rock, rock to be milled, and rock to be leached can minimize the amount of dilution that occurs during blasting and subsequent mucking and hauling. Image-processing techniques are being used to perform pre-blast rock-mass characterization and post-blast fragmentation analysis. These analyses are then used to evaluate the effectiveness of geophysical and x-ray fluorescence data in improving blast design and routing of blasted rock. The ultimate goal of the project is to integrate geophysical and XRF data with drilling data to create an adaptive, online analysis tool to optimize subsequent drilling and blasting.

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Project Recognition

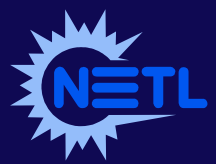
- **Paper presented and published in *Pacific Rocks 2000, Proceedings of the Fourth North American Rock Mechanics Symposium,* Seattle, July 31-August 3, 2000, "Blasting Optimization Using Seismic Analysis and X-Ray Fluorescence Spectroscopy," D. Hopkins, R. Haught, M. Karaca, D. Turler, L. Myer, J. Kemeny, P. Lever, and M. L. Lowery**
- **Presented at Geological Society of America Annual Meeting, November 9-18, 2000, Reno, Nevada, "Micromechanical behavior of joints and faults under shear stress," A. Marache, D. Hopkins, J. Riss, and S. Gentier.**
- **Two papers accepted for presentation and published in Proc. 38th U.S. Rock Mechanics Symposium, July, 2001, Washington D.C.:**
  - "Improvements in Blast Fragmentation Models Using Digital Image Processing," J. Kemeny, R. Kaunda, and E. Mofya.
  - "Characterization of the Parameters that Govern the Mechanical Behavior of Rock Joints in Shear," G. Grasselli, P. Egger, J. Wirth, and D. Hopkins

Project Recognition

- **Paper presented at the Society for Mining, Metallurgy, and Exploration (SME) conference in Arizona, 2002, " Improved Process Control Through Real-Time Measurement of Mineral Content," D. Turler, M. Karaca, W.B. Davis, R. Giauque, and D. Hopkins**
- **Two papers accepted for presentation and published in Mining and Tunnelling – Innovation and Opportunity, North American Rock Mechanics Symposium (NARMS), July 7-10, 2002, Toronto, Canada:**
  - "Drilling and Blasting Optimization Using Geophysical Analysis and X-Ray Fluorescence Spectroscopy," D. Hopkins and J. Kemeny
  - "Effect of Blasting on the Crushability and Grindability of Rock Fragments," J. Kemeny, R. Kaunda, E. Mofya , D. Streeter, T. Dangi and G. Perry

Commercialization Outlook - 1

- **Three technologies under development as part of the project have strong potential for commercialization:**
  - Geophysical rock-mass characterization system
  - Prototype system for sampling and analyzing the mineral content of dust/cuttings obtained during drilling
  - Online adaptive blast-design tool based on analysis of data collected during drilling and post-blast fragmentation analysis



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Commercialization Outlook - 2

Plans and time frame for commercialization

Geophysical rock-mass characterization system

Commercialization potential depends on value added by additional information gained from geophysical measurements under investigation. A system based on vibration measurements made on the drill rig has the shortest path to commercialization because it can be incorporated into existing commercial systems that collect and display other drill data. The project's drilling partner is interested in commercializing the technology if it proves viable, so that commercialization within a timeframe of 1-2 years is possible.

Commercialization Outlook - 2

Plans and time frame for commercialization (cont'd)

Geophysical rock-mass characterization system

The commercialization potential of field geophysical systems such as cross-hole radar depends on the value of the data. Costs are higher than for systems that can be deployed on the drill rig because of increased labor costs. Incorporating the geophysical data with other drilling data is less straightforward because it would not be collected at the same time. However, the data collected is likely to be more easily interpreted than data collected on the rig, and equipment to measure data is well developed and commercially available. Time to commercialization of a stand-alone system including software to analyze and visualize data is on the order of 1-2 years. Commercialization timeframe for a system integrated with other drill and rock-mass data is on the order of 2-3 years.

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Commercialization Outlook - 3

Plans and time frame for commercialization

Prototype system for sampling and analyzing the mineral content of dust/cuttings obtained during drilling

Work to date has demonstrated the feasibility of collecting samples during drilling and using x-ray fluorescence (XRF) spectroscopy to analyze mineral content. There are several paths to commercialization. An integrated sample collection and real-time mineral-content analysis system could be built either as a stand-alone system, or integrated with existing software packages that collect and display other drill data. The technology for sampling dust/cuttings during drilling can be commercialized separately; in this scenario the samples would be analyzed off line, e.g., in the mine's assay lab.

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Commercialization Outlook - 3

Plans and time frame for commercialization (cont'd)

Prototype system for sampling and analyzing the mineral content of dust/cuttings obtained during drilling

Commercialization would be pursued with companies manufacturing drill rigs or equipment for rigs; companies have expressed an interest in the technology. The XRF analysis and display system can also be commercialized separately; in this scenario the portable system would be used by mining personnel to obtain real-time measurements of mineral content in the field using existing sample-collection techniques. Integrating analysis and display software developed for the project with commercially available portable XRF systems is the fastest path to commercialization for this technology, and could be achieved within 1-2 years.

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Commercialization Outlook - 4

Plans and time frame for commercialization

Online adaptive blast-design tool based on analysis of data collected during drilling and fragmentation analyzed after blasting

Work to date has demonstrated the feasibility of integrating drilling, rock-mass, blasting and post-blast fragmentation data to improve blast design. Data from field tests has been used successfully to improve blast fragmentation models. Thus, an adaptive blast-design tool that would allow blasting engineers to better optimize blast parameters including the location of boreholes, the charge per hole, and the timing of detonation, has strong commercialization potential. With this system, blasting could be optimized for specific downstream processes on a hole-by-hole basis, and would be applicable to most any process including crushing and grinding, leaching, and disposal on a waste pile.

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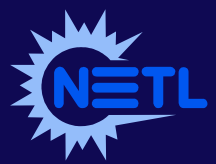
Commercialization Outlook - 4

Plans and time frame for commercialization (cont'd)

Online adaptive blast-design tool based on analysis of data collected during drilling and fragmentation analyzed after blasting

One path to commercialization is to integrate the blast-design tool with existing commercial systems that collect and display data while drilling. The time frame for commercialization is on the order of 2-3 years. The blast-design tool can also be commercialized as a stand-alone system, in which case all relevant data would be integrated and analyzed offline to produce a blast design. In this case the time-frame for commercialization is 1-2 years.



Development of Machine Fluid Analysis Systems

- **Principal Investigator:** Bob Francini,
  Pacific Northwest National Laboratory
- **NETL Project Manager:** Morgan Mosser
- **Partners:** Belhaven Applied Technologies, Oil Analysis Lab, CONOCO, Pall Corp.
- **Total Project Cost:** **$1,700K**
  - DOE Share: $850K
  - Participant Share: $850K
- **Project Period:** **36 months**
- **Project Start Date:** **September 1999**
  - No cost time extension till May 31, 2003

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Project Objectives

- Develop systems that allow on-board or on-site analysis of lubricating and hydraulic fluids for mining equipment, to provide near real-time diagnostic / prognostic information on equipment health

- Implement advanced condition-based maintenance systems to decrease downtime, increase equipment life, enable more efficient equipment use, and reduce oil in waste streams

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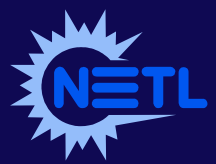
Milestones and Status

Major Milestones Planned to Date/Status

Planned Milestone	***Scheduled***	***Completed***
– Design and fabricate prototype bench-top system for diesel lube oils	06/2000	06/2000
– Optimize sensors and software for use with synthetic oils found in hydraulic systems	09/2000	10/2000
– Demonstrate system technology at Kennecott Copper Mine Site in South Jordan, UT.	08/2001	09/2001
– Fabricate and demonstrate on-board/on-site fluid analysis systems for mining equipment	04/2003	



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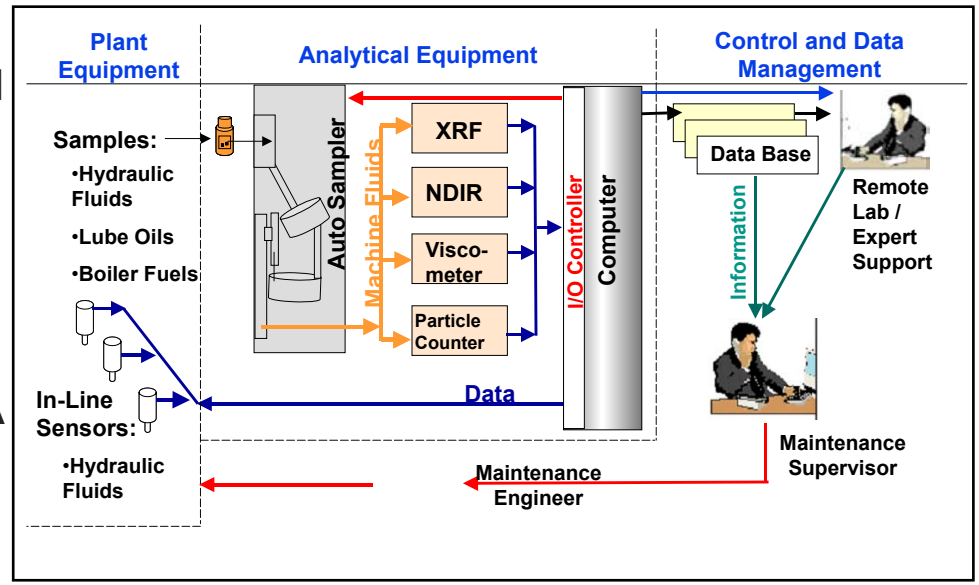
Key Accomplishments

- **Project Highlights**
  - Technology developed under this project has recently selected for use in the pulp and paper industry. A system adapted for this applications will be installed at the PCA paper mill in Counce, TN.
  - A new 30 channel version of the original 4 channel NDIR has been built and tested. This new sensor system is shown at the right.



Removable cell for grab samples

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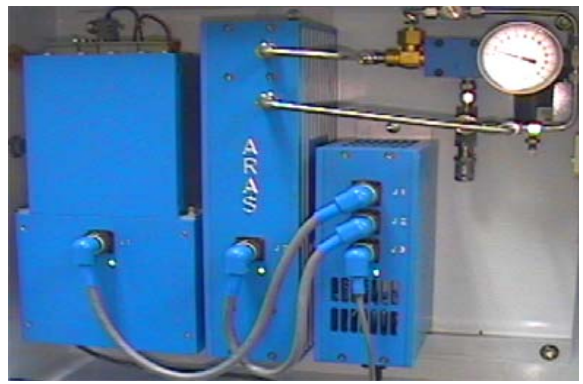
Key Accomplishments (Cont'd)

- **Project Highlights (Cont'd)**

We have received preliminary written notification of allowance for several key claims on the parent oil analysis system patent filing. This patent protection enhances the value of the technology and helps ensure that development by the manufacturer will continue.

In-line system for dedicated use on a gas turbine engine is shown at right. The system comprises an oil debris monitor and an infrared analyzer. The system been successfully tested at a Navy laboratory and has been installed on the USS Barry guided missile destroyer.

In-line engine oil monitor installed on U.S. Navy DDG

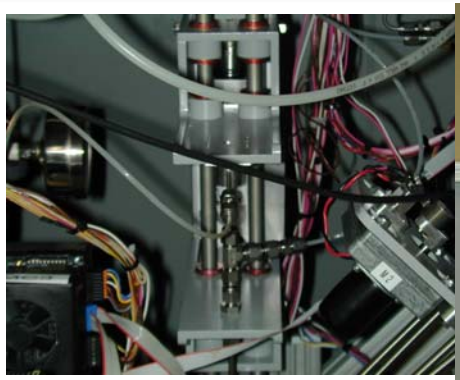


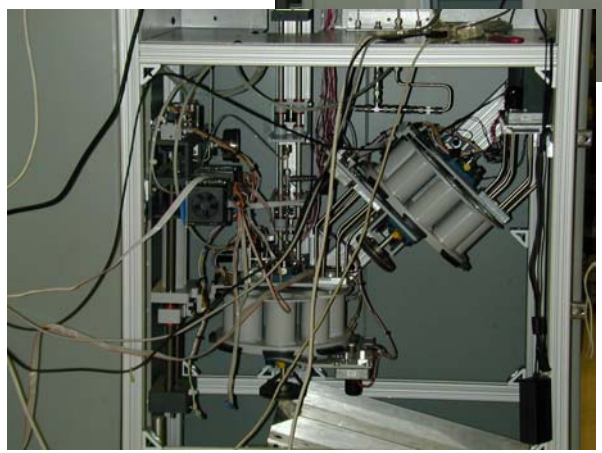
Project Highlights (Con't)

- Control and user interface software for the on-site system is being re-written to run in the National Instrument Lab View environment. The Labview code for the XRF, NDIR and viscometer are complete. The program to for motion control of the AutoSampler is complete. Integration of the sensors into the system has been started.
- Conoco / OAL has determined that the first system will now be deployed at OAL for initial testing. Samples from the Bingham Canyon mine site in UT will be among the first mining samples to be analyzed.
- Pall Corporation has decided to withdraw as a sponsor for this project after determining that its interest lies in other markets. Pall corporation had joined as an industrial partner in FY 02 and had selected the Solvay site in Wyoming for demonstration of a second stand-alone system. As a result, this system will not be deployed.
- A miniature XRF sensor that is smaller and more sensitive than the earlier version has been developed to the laboratory demonstration phase.

Project Highlights (Con't)

- The AutoSampler system has been built and testing of the computer automation completed.
- The motion control program for autosampler is complete.
- The XRF, viscometer, particle counter and NDIR have been integrated into the system.





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Good News!

The specific objective of the project work is to demonstrate on-board and on-site machine fluid analysis on mining equipment. The longer range objective of this effort is development of technology that will to enable true condition-based maintenance on mining equipment. This includes creating the sensors, micro-processors, software and communications technologies to allow both the diagnostics and prognostics needed to increase reliability, reduce life-cycle costs, allow for just- in-time inventory and supply of replacement parts, and shorten repair times

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Good News! (Cont'd)

We have made significant progress toward these goals with the development /adaptation of the required sensors and sensor control software. The main thrust in 2003 will be the fabrication and **delivery** of a robust sample handling/sample input device and a field demonstration of the system. Upgrades based on field results and early commercial orders for the equipment for non-mining applications will move the system closer to commercialization for on-site and on-board use in both open pit and underground mine applications.

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Commercialization Outlook

- A non-exclusive license for manufacture, sale and use of the technology developed under this program has been granted to Belhaven Applied Technologies in Kennewick, WA.
- As licensee, Belhaven has received orders for one or more systems in each of two new configurations, one for marine propulsion diesel and one for a railroad locomotive application.
- ARTI, a small company in Grants Pass Oregon, is negotiating for rights to manufacture a combined IR/particle counter system based on the technology developed under this program.
- A patent application has been filed for the upgraded miniature XRF system developed under this project (see Highlights).
- DOE OIT project industrial partners will have first-in-line rights to license background IP.

Project Recognition

- Wilson, B.W. and Silvernail, G: "Automated In-Line Machine Fluid Analysis for Marine Diesel and Gas Turbine Engines," Proceedings: Technology Showcase 2002, JOAP International Condition Monitoring Conference, Mobile AL, April 7-11 2002.
- Wilson, B.W., NH Hansen, G, Silvernail, B.Cross: "Modular System for Multi-Parameter In-Line Machine Fluid Analysis." Proceedings: Technology Showcase 2000, JOAP International Condition Monitoring Conference, Mobile, AL. April 3-6 2000. Joint Oil Analysis Program Technology Center Pensacola.
- Wilson, BW and Price LS:On-Board X-Ray Fluorescence Analysis System. *Lubrication and Fluid Power*, Vol. 1 pp 36-38 (2000).
- Wilson, B. W., N. H. Hansen, C. L. Shepard, T. J. Peters, and F. L. Greitzer: "Development of a Modular In-Situ Oil Analysis Prognostic System." Proceedings, SOLE '99 Symposium, Las Vegas, NV. 1999

RIM System for Imaging Ahead of Mining

- **Principal Investigator:** Marianne Walck - Sandia National Laboratories
- **NETL Project Manager:** Morgan Mosser
- **Partners:** Stolar Horizon, Inc; CONSOL, Inc.; Kennecott
- **Total Project Cost:** **$1,544K**
  - DOE Share: $212K
  - Participant Share: $1332K
- **Project Period:** 48 months
- **Project Start Date:** October 1999
  - No cost time extension to September 30, 2003

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Project Objectives

- Validate, with in-mine testing, an advanced Radio Imaging Method (RIM) system that will provide accurate information on the location of the anomalous geologic conditions within an ore body prior to mining

- Employ RIM system to improve the quality of mined ore, reduce wear on mining machinery, facilitate mine operations, and reduce costs

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Milestones and Status

Major Milestones Planned to Date/Status

Planned Milestone

	Scheduled	***Completed***
- In-Mine RIM-IV System Complete	Sept 02	100%
– RIM data collected at Mine 1	Oct 02	100%
– RIM data collected at Mine 2	Nov 02	100%
– Down-Hole RIM-IV system complete	Feb 03	100%
– Mines #1 & #2 deliver ground truth data	March 03	100%
– SH completes FWIC inversion	May 03	50%
– Acquire MSHA approvals for RIM	May 03	50%
– SNL delivers final report to DOE	Sept. 03	0%

Key Accomplishments

- **Project Highlights**
  - The electronics and packaging are complete for both the In-Mine and Down-Hole RIM-IV Systems. MSHA certification (for flame-proofing and intrinsic safety) is in process.
  - In-Mine RIM-IV has been tested 10 times in an underground environment.
    1. Sanborn Creek Mine, Oxbow - Colorado, USA (December, 2001)
    2. Mine 84 - Pennsylvania, USA (April 2002)
    3. Deserado Mine - Colorado, USA (July 2002)
    4. Genwal Mine - Utah, USA (August 2002)
    5. Genwal Mine - Utah, USA (October 2002)
    6. Mine 84 - Pennsylvania, USA (November 2002)
    7. Daw Mill Colliery - Warwickshire, UK (January 2003)
    8. Daw Mill Colliery - Warwickshire, UK (February 2003)
    9. North Goonyella Colliery, RAG - Qsld, Australia (March 2003)
    10. Crinum Colliery, BHP - Qsld, Australia (March 2003)
  - Tomography images have been generated for 5 of the above

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Key Accomplishments

Imaging Transmitter Module and a Synchronization Transmitter Module

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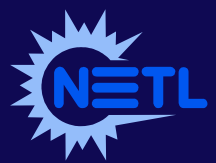
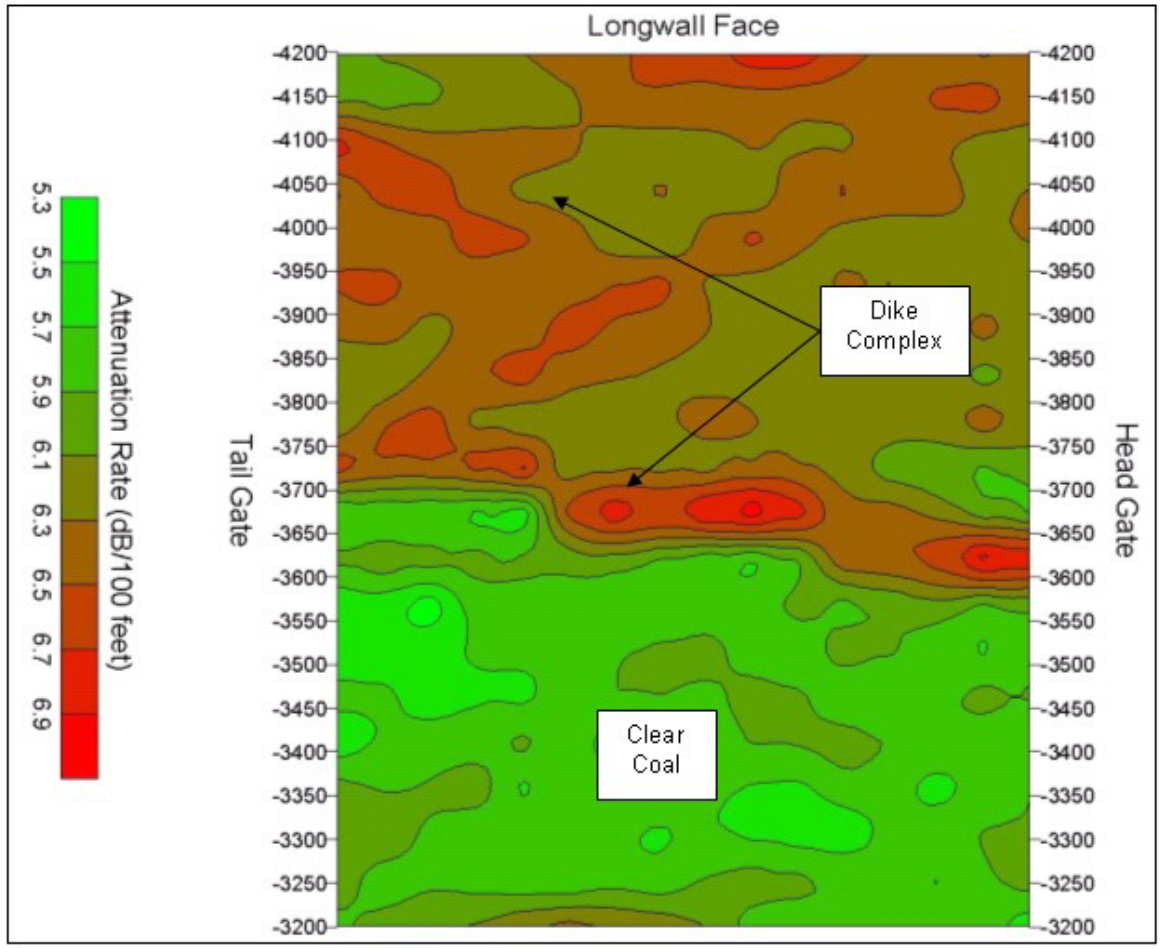
Key Accomplishments

- **Project Highlights**
  - Latest field tests show RIM IV system capable of 2000 feet range with phase stability greater than 3 degrees.
  - There are now seven imaging frequencies available: 22.5, 40, 52.5, 70, 80, 200, and 300 kHz.
  - The In-Mine system can be mechanically reconfigured for Down-Hole use with only an antenna and fiber-optic change.
  - RIM In-Mine and Down-Hole versions of RIM IV are being produced in small quantity at Stolar.



Key Accomplishments



RIM-IV tomographic image of Genwal's No. 18 longwall panel as surveyed 21 October 2002

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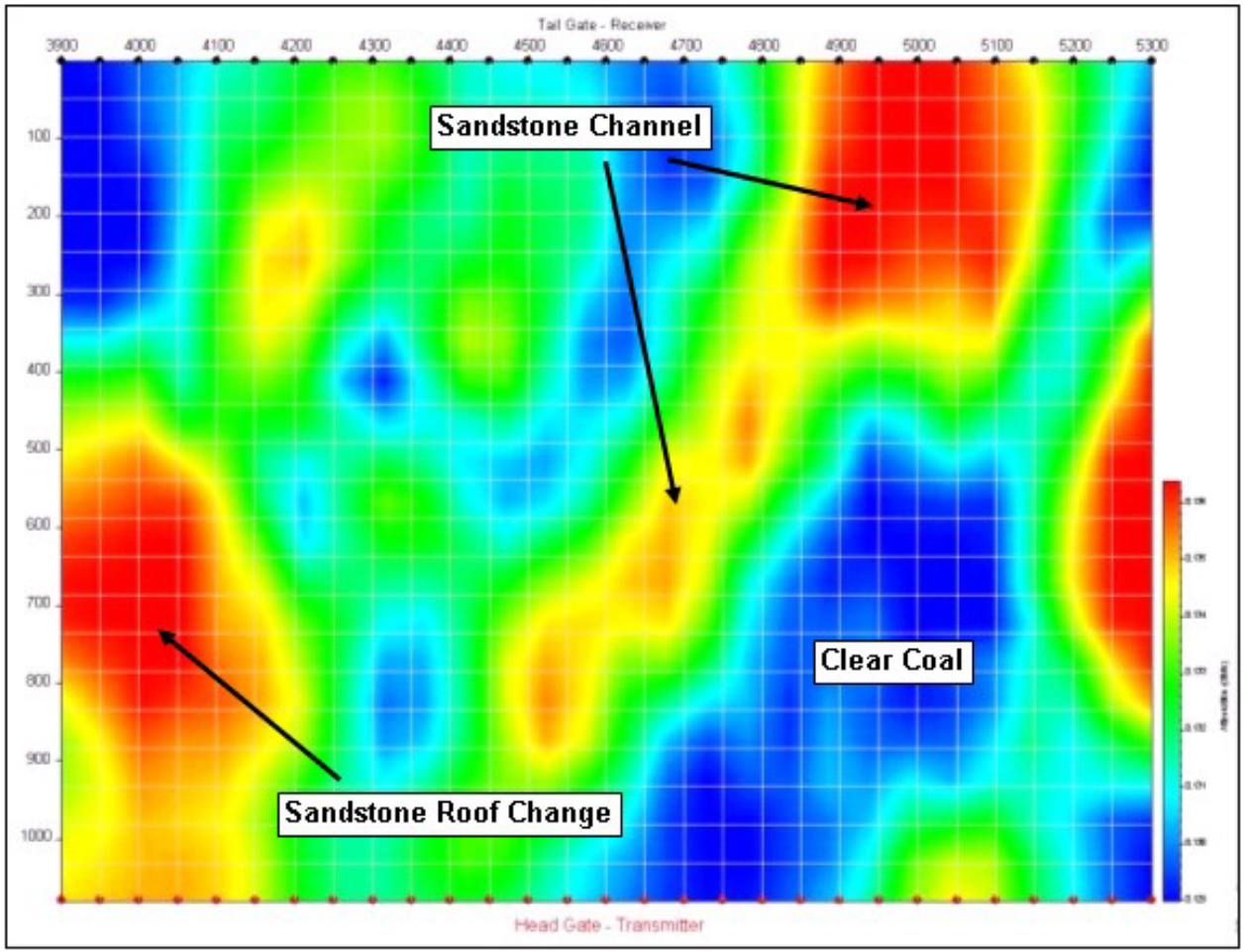
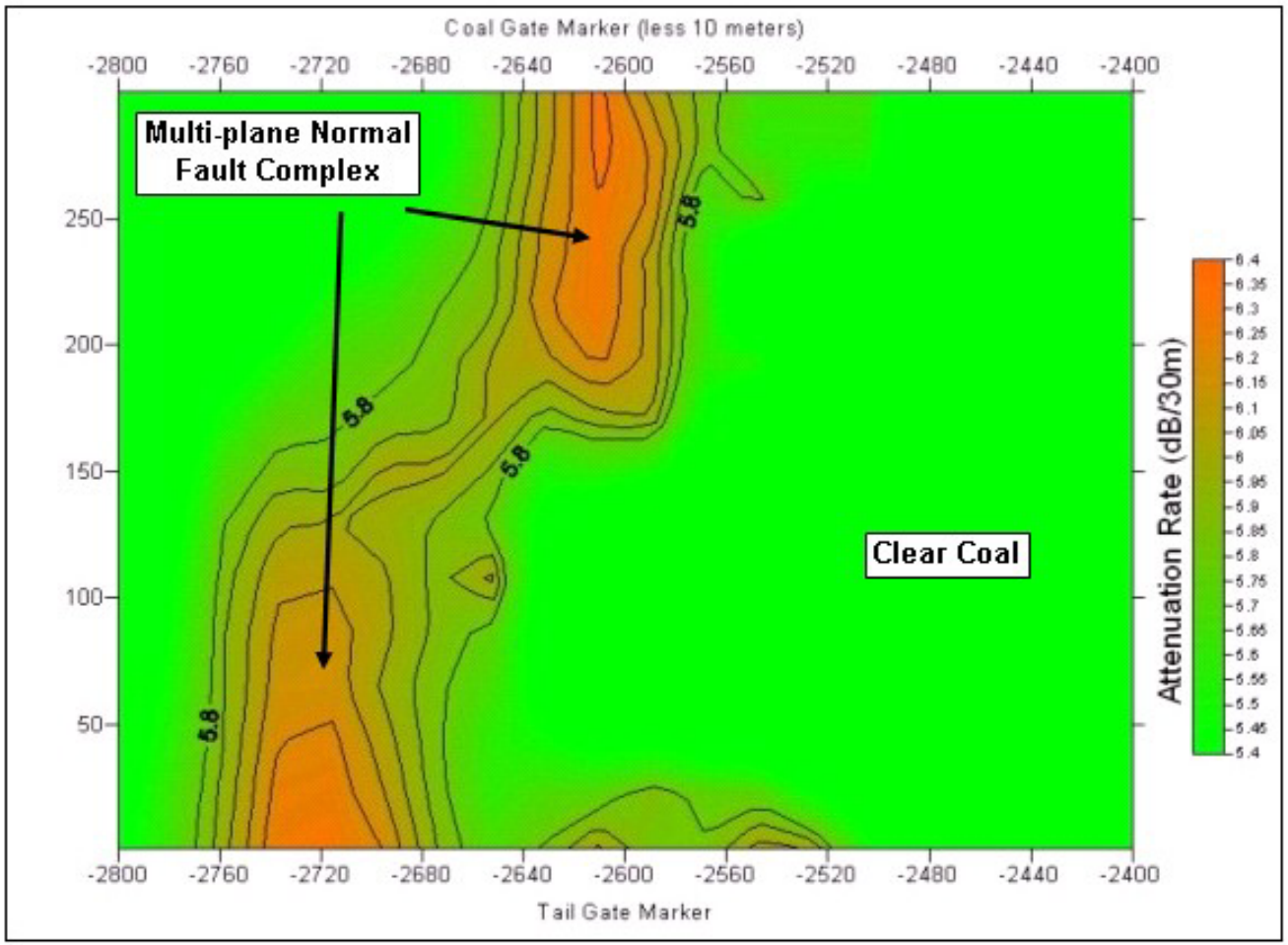
Key Accomplishments



RIM-IV tomographic image of Mine 84's 1B longwall panel as surveyed 4 November 2002

Key Accomplishments



RIM-IV tomographic image of Daw Mill's No. 301 panel as surveyed 4 February 2003

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Project Recognition

- *"Crosswell Systems for Imaging Ahead of Mining",* T. W. H. Caffey, National Mining Association Convention, 10-13 October 1999, St. Louis, MO
- "The Smart World of Mining", World Coal Magazine, May 2001, p 51-54
- "Breakthrough Technology", World Coal Magazine, May 2002, p 23-26
- "A Clearer Image", World Coal Magazine, Vol. 11 No. 12, December 2002
- "Sensing the future", World Coal Magazine, May 2002

  Release Pending

Commercialization Outlook

- The Stolar Global Center for Geologic Interpretation has continued to perform geologic imaging and geotechnical consulting on a “Field Service” level.
- Lease options are being structured that would allow a customer to maintain possession of the system and perform survey when needed under the supervision of SGCGI’s geophysicist and geologists.
- Sales efforts currently include marketing of In-Mine RIM-IV, Down-Hole RIM-IV, and RIM-based risk reductions to the coal mining industry.
- Credit Suisse First Boston offers loan rate reductions to coal companies that will use RIM IV in mine development.

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